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Cardiovascular Consequences of Unfair Pay

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ABSTRACT

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This paper investigates physiological responses to perceptions of unfair pay. In a simple principal agent experiment agents produce revenue by working on a tedious task. Principals decide how this revenue is allocated between themselves and their agents. In this environment unfairness can arise if an agent's reward expectation is not met. Throughout the experiment we record agents' heart rate variability. Our findings provide evidence of a link between perceived unfairness and heart rate variability. The latter is an indicator of stress-related impaired cardiac autonomic control, which has been shown to predict coronary heart diseases in the long run. Establishing a causal link between unfair pay and heart rate variability therefore uncovers a mechanism of how perceptions of unfairness can adversely affect cardiovascular health. We further test potential adverse health effects of unfair pay using data from a large representative data set. Complementary to our experimental findings we find a strong and highly significant association between health outcomes, in particular cardiovascular health, and fairness of pay.

JEL Classification: D03, D63, I14, C91

Keywords: fairness, social preferences, inequality, heart rate variability, health, experiments, SOEP

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1. Introduction

A large and growing body of evidence suggests that fairness perceptions play an important role in labor relations, affecting work morale, effort provision and market efficiency (see, e.g., Fehr, Kirchsteiger and Riedl 1993; Fehr, Gächter and Kirchsteiger 1997; Altmann, Falk and Huffman 2010)[1]. This work points out adverse behavioral consequences of unfair pay. The present paper instead provides evidence on adverse effects at the physiological level. In particular we investigate the potential impact of unfair pay on heart rate variability (HRV). The economic importance of studying the relation between fairness perceptions and HRV results from the fact that the latter is an early indicator of functional and structural impairments of the cardiovascular system, which increases the probability of future manifest coronary heart disease (Steptoe and Marmot 2002, Dekker et al. (2000), Gianaros et al. (2005)). In other words, establishing a causal link between unfair pay and HRV would suggest that on top of behavioral consequences, perceptions of unfair pay can have important negative health consequences, in particular on stress-related cardiovascular health.[2]

We proceed in two steps. First, we report results from an experiment that tests our hypothesis that fairness perceptions have a causal effect on HRV. Second, and based on this main contribution, we analyze data from a large representative data set to check whether perceptions of unfair pay are related to health status in the general population.

The experiment implements a simple principal agent relationship. In the experiment the agent produces revenue by working on a tedious task. The principal receives the revenue

[1] For an overview and related studies, see Fehr and Gächter (2000). The above cited experimental work is complemented by interview studies with personnel managers (see, e.g., Agell and Lundborg 1995; Bewley, 1999, 2005). Akerlof (1982) provides an early theoretical analysis of fairness and labor market efficiency.

[2] The global public health and economic burden of cardiovascular disease is immense. By the year 2020, coronary heart disease, together with major depression, is estimated to be the leading cause of life years lost to premature death and years lived with disability worldwide (Mathers, Lopez and Murray 2006). Among adult populations of high income countries, coronary heart disease is the leading cause of death, and cost of illness studies estimate that almost one percent of the gross national product is attributable to the direct and indirect costs of coronary heart disease (Liu et al. 2002).

produced by the agent and decides how to allocate it between the agent and himself. Unfairness can arise in this set-up if an agent's reward expectation is not met, i.e., if an agent perceives his payment as unfairly low. The agents' HRV is monitored throughout the experiment.

The experimental set-up allows us to precisely measure revenues, actual payment shares as well as agents' perceptions of appropriate or unfair pay. In the analysis we use two indicators of perceived unfairness. The first one is simply the share agents receive from total revenue, capturing deviations from an equitable allocation. The second measure uses subjectively stated perceptions of fair pay, which accounts for heterogeneity in perceptions of fairness and social preferences (Dohmen, Falk, Huffman and Sunde, 2008; Fischbacher, Gächter and Fehr, 2001; Fischbacher and Gächter 2010). This second measure is defined as the discrepancy between actual share and "appropriate" share. Our main hypothesis to be tested is an inverse[3] relationship between the degree of unfairness, as measured by our two indicators, and HRV, our indicator for impaired cardiac autonomic control. The experimental results support this hypothesis. Both measures of unfairness, actual share, and discrepancy between actual and appropriate share, are inversely related to agents' degree of impaired cardiac autonomic control, measured by HRV. This result is confirmed with elicited survey measures for mood, anger, and perceived fairness of the exchange. These survey measures are all significantly correlated (in the expected direction) with the two experimental measures of fairness. This indicates that agents interpret the experimental outcome in terms of fairness and are emotionally affected in a systematic way.

In light of our causal laboratory evidence and the significance of HRV as an indicator for stress-related cardiovascular health, we further tested whether perceptions of unfair pay

[3] Note that low heart rate variability is observed, among others, during states of mental stress while enhanced heart rate variability occurs during states of mental relaxation (for details and references, see Section 2). This is why we expect an inverse relationship between unfairness and HRV.

are negatively correlated with health status. We investigate this hypothesis with data from the Socio Economic Panel (SOEP), a large data set that is representative for the adult German population. In particular we regress employees' subjective health status on whether they consider their income as fair or unfair. Controlling for a large set of personal as well as labor market characteristics (such as net wages, labor market status, occupational status, firm size, industry) we find a strong and highly significant association between unfair pay and lower subjective health status. Moreover, when we test the effect of unfair pay on the incidence of particular diseases, we find that fairness perceptions affect health outcomes related to the experience of stress and the nervous system, such as heart disease and blood pressure, while no such effect is observed for diseases such as cancer or apoplectic stroke. These results provide complementary evidence to our experimental findings. Both demonstrate potential negative health effects as a reaction to perceptions of unfair exchange at work.

Our work is related to epidemiological research, suggesting that people who are confined to demanding jobs that fail to compensate efforts by "adequate" rewards are at increased risk of suffering from stress-related disorders, such as cardiovascular disease and depression (for a review, see Siegrist, 2005). Other studies suggest that economic inequality in general contributes to the development of cardiovascular disease in a significant way.[4] Different from our experimental approach, however, it is generally difficult to establish causal relationships with epidemiological data. Moreover, reliable measures of perceived fairness of pay as well as large sets of control variables are typically not available. Finally, uncovering specific psychobiological processes that are elicited by experienced unfairness requires the use of biomarkers.

[4] This was documented in epidemiological investigations using different indicators such as low income (McDonough et al. 1997), income inequality (Kennedy et al. 1996; Wilkinson 1996), or perceived unfairness resulting from an imbalance between efforts spent and rewards received at work (Bosma et al. 1998; Kivimäki et al. 2002; Kuper et al. 2002; Lynch, Kaplan and Shema 1997). Wilkinson and Pickett (2009) discuss large-scale effects of inequality.

In the next section we present our experimental design as well as our hypotheses. Section 3 reports our main results, section 4 concludes.

2. Experimental design and procedural details

We implemented a simple principal agent relationship. Upon arrival to the lab, subjects were assigned to the role of an agent or a principal. Subjects received all instructions via computer screen. We used z-Tree as computer software (Fischbacher 2007). Agents received a pile of numbered sheets. On each sheet there was a table containing a large number of zeros and ones. The work task was to count the correct number of zeros for a given sheet and to type it into the computer. Working time was 25 minutes. Each correctly entered number per sheet created revenue of 3 Euro. The accumulated revenue was shown to agents on the screen. Agents were explicitly told that they could complete as many sheets as they wanted to, including to complete no sheet at all. Principals did not work and were told that they were free to do things like reading newspapers or doing homework. After the 25 minute working time was over each principal was informed about the accumulated revenue and was asked to allocate it between himself and the agent. Before the principal's allocation decision was communicated to the agent, the latter was asked to state the amount of money he considers an "appropriate pay". This information was not revealed to principals. The agent was then informed about the principal's actual allocation decision. Starting with this feedback, the agent was given a time window of 4 minutes to silently cope with this information. This time window was selected for analysis of HRV.

At the end of the experiment we ran a short survey. We elicited psychometrically validated measures of general mood (Steyer et al. 1997) and anger (Spielberger 1988). In addition, we measured perceived fairness of the economic exchange using the item: "In your view, how fair was the return you received from your principal?". Answers were given on a 5-point Likert-scale.

Subjects were students from the University of Bonn studying various majors except economics. They gave their informed consent to participate in the experiment. Exclusion criteria were the use of medication with potential interference with cardiovascular function or the presence of a chronic disease condition, such as hypertension, cardiac arrhythmias, coronary heart disease, or diabetes. In total 80 subjects participated in the experiment (40 principals and 40 agents). During the process of data analysis, we had to exclude data of 10 subjects in the role of agents, due to incomplete or invalid heart rate measurements. As registration of cardiovascular parameters was restricted to the group of agents, the main analysis is based on 30 subjects in the role of agents with complete data. Note that the 10 subjects that were excluded due to incomplete heart rate measurements were not different neither in their behavior nor treatment by their principals, compared to the 30 subjects the analysis is based on (see Footnote 6).

The physiological measures of the agents' autonomic nervous system activity were heart rate (HR) and heart rate variability (HRV) as established indicators of stress-related activation of the autonomic nervous system (Task Force 1996; Steptoe and Marmot, 2002). Cardiac autonomic control is assessed by continuously monitoring heart rate and HRV. This latter measure reflects the continuous interaction of sympathetic and vagal influence on heart rate, indicating an individual's capacity to generate regulated physiological responses to demanding situations (Appelhans and Luecken 2006). Low HRV mirrors a decreased vagal tone with sympathetic predominance and is observed, among others, during states of mental stress (von Borella et al. 2007). Conversely, enhanced HRV occurs during states of mental relaxation (Vermunt and Steensma, 2005).[5]

[5] At the beginning of the experiment a polar F810i device (polar electro OY, Kempele, Finland) was attached to record and store time intervals between consecutive heart beats (IBI, inter-beat-interval). Agents were instructed to remain seated during the whole experiment and to restrict all movements, with the exception of their dominant arm operating the computer. The target time window for physiological recordings lasted 4 minutes. Data were transmitted to a PC, stored, and analyzed offline by a researcher who was blind to the psychological

3. Results

In this section we present our main results. We first report our findings from the experiment. Second, we briefly investigate the relation between perceptions of unfairness and health status using representative data.

3.1. Experimental results

In our analysis we focus on two measures of how fair the principals' allocation decisions are perceived. The first one is simply the actual share received *s*, i.e., the ratio of received pay by an agent *i*, π_i, and total revenue, r_i, i.e., $s_i = \pi_i/r_i$. The lower the *actual share*, the higher is the difference between performance-related and actually received payment. Our second fairness measure allows for subjectively different perceptions of fairness and uses each agent's individual perception of an appropriate pay, π_i'. The *appropriate share*, a_i, is therefore $a_i = \pi_i'/r_i$. Our second fairness indicator measures the *discrepancy* between actual and appropriate share. It is defined as $d_i = s_i/a_i$.[6] A value of one implies that the principal exactly meets the expectation of the agent, values below one indicate a disadvantageous discrepancy between actual and appropriate payment.

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outcome measures. After visualizing and manually correcting data for artefacts a smoothness priors method was used to remove trends of the IBI time series. Then, a HR time series was derived and the following time-domain based HRV indices were calculated: SD-IBI (standard deviation of the IBI series), SD-HR (standard deviation of the HR series), and RMSSD-IBI (root mean square of successive differences of the IBI series) (Niskanen et al. 2002). The RMSSD-IBI represents a sensitive index of parasympathetically-dominated, respiratory related, fast fluctuations of HR, and can be calculated with milliseconds precision. It is considered to accurately index resting vagal tone directed to the heart and was documented to be rather resistant to the biasing effects of breathing (Penttilä et al. 2001). As SD-IBI and SD-HR are highly correlated with RMSSD-IBI we restrict the presentation of findings to RMSSD-IBI as a robust and well validated time-domain based indicator of parasympathetic cardiac control. All calculations were done with a computer program for advanced HRV analysis (Niskanen et al. 2002).

[6] Conceptually we like to introduce d_i in terms of shares, but of course d_i can also expressed as $d_i = s_i/a_i = \pi_i/\pi_i'$. Note that higher values of d_i imply less discrepancy.

In Table 1 we report means and standard deviations of our main variables[7]. On average agents produced a total revenue of 20.9 Euro and indicated that they would consider an average share of 0.66 as appropriate. This contrasts sharply with what agents actually received. On average agents were paid an actual share, $s = 0.43$, i.e., principals allocated 43 percent of total revenue to their agents. Averaging all individual differences between actual and appropriate share leads to a mean score of d_i of 0.69, which is clearly below 1.

Table 1: Descriptive statistics

Variable	**Mean**	**Standard Deviation**
Total Revenue produced by agents (r_i) (in Euro)	20.9	8.57
Actual share (s_i)	0.43	0.14
Appropriate share (a_i)	0.66	0.16
Discrepancy ($d_i = s_i/a_i$)	0.69	0.29
Fairness Questionnaire (scale: 1-5; higher values imply "more fair")	2.56	1.43
Mood Questionnaire (scale: 4-20; higher values imply "better mood")	13.27	4.38
Anger Questionnaire (scale: 10-40; higher values imply "more anger")	18.20	8.28
Heart rate variability (RMSSD)	32.33	11.25

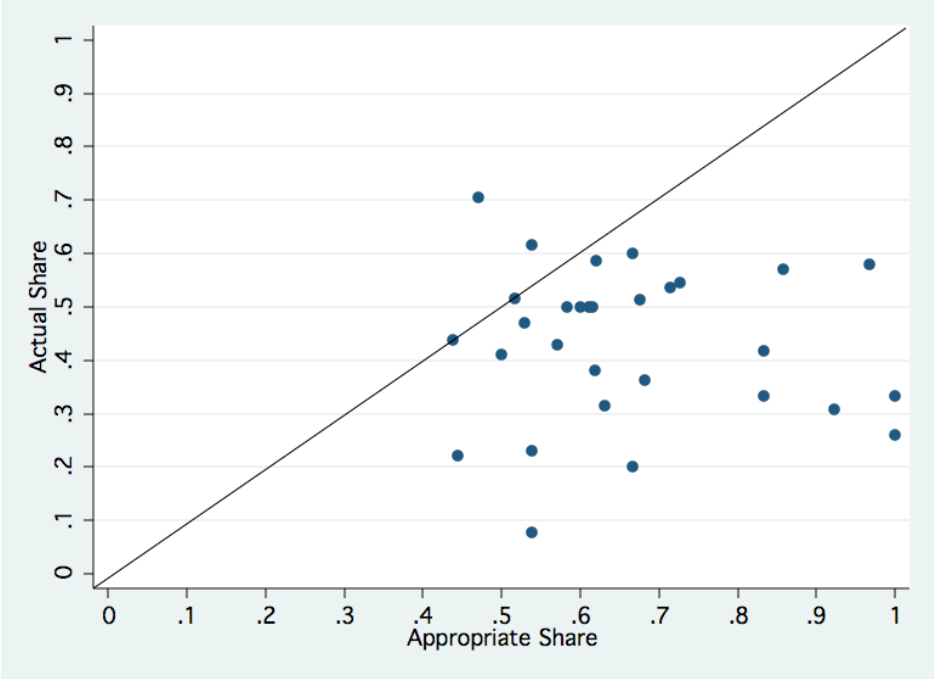
Mean and standard deviation (SD) for each variable included in the analysis (N = 30).
Actual share is the ratio of received pay by the agent, π_i, and total revenue, r_i, i.e., $s_i = \pi_i/r_i$.
Appropriate share is the ratio of appropriate pay, π_i', and total revenue, r_i, i.e., $a = \pi_i'/r_i$.

Figure 1 displays the discrepancy between appropriate and actual share individually for all agents. The figure shows that almost all agents thought that they should get at least fifty percent of total revenue. Moreover, almost all observations are below the 45-degree line, meaning that, with very few exceptions, agents actually received less than they thought would

[7] Table 1 reports data for the 30 subjects with complete heart rate measurement. Subjects with incomplete measurement were not different in any systematic way. For example total revenue for this group was 20.2 (Std. dev. 7.23), which is not significantly different from total revenues reported in Table 1 (OLS regression with a dummy for excluded subjects yields a p-value of 0.809). Corresponding p-values are 0.412, 0.881 and 0.610 for actual shares, appropriate shares and agents' profits, respectively.

be appropriate. The figure also shows that the discrepancy between actual and appropriate shares varies considerably between subjects, i.e., the experiment generates substantial variation in perceived fairness violations. This heterogeneity and the fact that principals were randomly assigned to agents allows testing our main hypothesis.

Figure 1: Discrepancy between actual and appropriate share received by agents. Actual share is defined as ratio between actual payment and total revenue; appropriate share is defined as ratio of appropriate payment and total revenue. The line is a 45-degree-line.

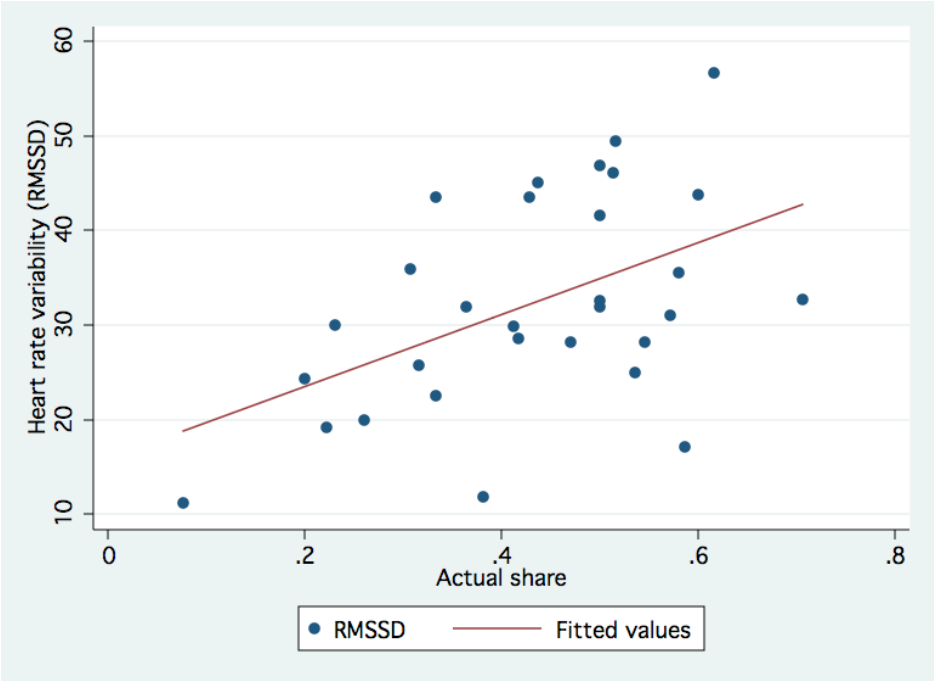


Figures 2(a) and 2(b) plot the two measures of perceived fairness against HRV, measured by RMSSD[8], during the observation period. Figure 2(a) shows a positive correlation between actually received share and HRV. Thus, as hypothesized, the higher the perceived unfairness, the lower is HRV. The Spearman rank correlation between these two variables is significant at any conventional level (Spearman's rho = 0.46; $p<0.01$). Figure 2(b) plots HRV against our measure for discrepancy, i.e., the ratio between actually received and appropriate share. Again, the correlation is positive and significant (Spearman's rho = 0.53, $p<0.01$). Put differently, the higher the discrepancy between obtained and appropriate rewards, the lower is

[8] See Footnotes 2 and 4.

mean HRV. Both results are confirmed by regression analyses, shown in Table 2, where coefficients for HRV are positive and significant both for actual share ($p<0.01$) as well as discrepancy ($p<0.01$), respectively[9]. We also find a significant relation between self-reported perception of fairness and HRV, again indicating an inverse relation between the degree of unfairness and HRV ($p<0.01$).

Figure 2(a): Relation between actual share and heart rate variability (RMSSD). The line is a weighted regression line.



[9] Results remain basically unchanged if we include total revenue as a control. Note further that HRV is not related to agents' work effort. When we regress total revenue (r_i) on HRV the coefficient is insignificant (OLS regression, N=30, t = 0.72). Regressions are available on request.

Figure 2(b): Relation between discrepancy and heart rate variability (RMSSD). Discrepancy is defined as ratio between actual and appropriate share. The lower the value for discrepancy, the larger is the discrepancy between actual and appropriate shares. The line is a weighted regression line.

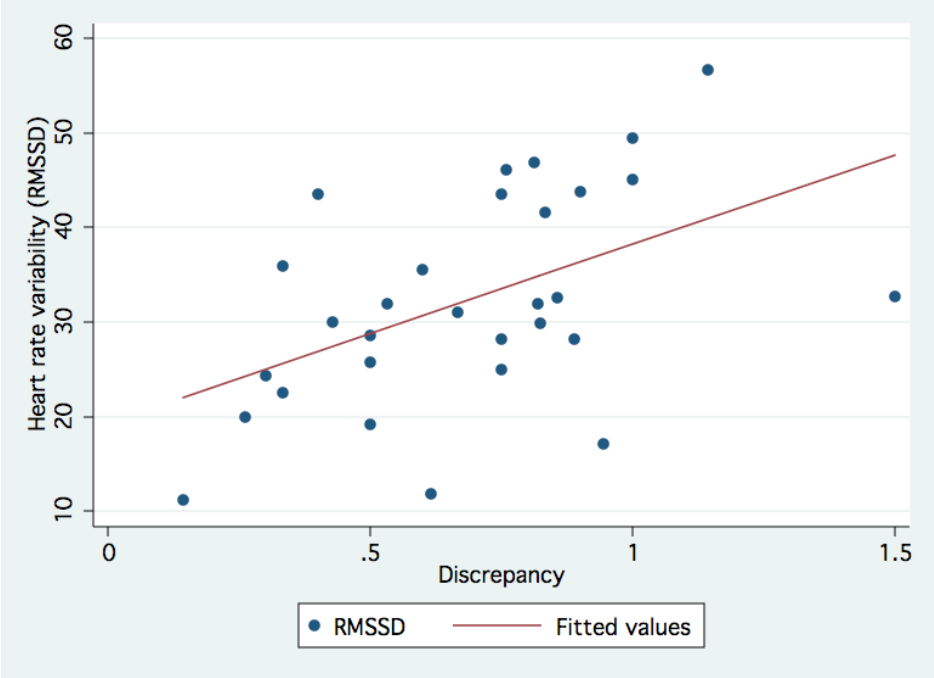


Table 2: Heart rate variability regressions

Dependent variable: Heart rate variability (RMSSD)			
Actual share	38.17***		
	[12.77]		
Discrepancy		18.87***	
		[6.29]	
Fairness (survey measure)			0.0668***
			[.0204]
Constant	15.84**	19.35***	0.4048
	[5.81]	[4.69]	[0.6986]
Observations	30	30	30
R-squared	0.24	0.24	0.28

OLS regressions with standard errors in brackets. ***, **, * indicate significance at 1-, 5-, and 10-percent level, respectively.

Table 3 confirms that our two experimental measures for perceived unfairness reflect subjects' perceptions and emotions. General mood, anger, and perceived fairness are all

significantly correlated in the expected direction with actual share and discrepancy. Subjects report being in a better mood, experience less anger and perceive payments as less unfair the higher the actual share and the lower the discrepancy between actual and appropriate share.

Table 3: Correlations of experimental and survey measures

	Actual share	Discrepancy
Fairness	0.70***	0.79***
Mood	0.56***	0.59***
Anger	- 0.58***	- 0.70***

Spearman rank correlations. *** indicate significance at 1-percent level; Number of observations = 30.

3.2 Fairness perceptions and health: representative data

Our experimental data show that the perception of an unfairly low wage induces impaired cardiac autonomic control. In view of the significance of our measure for stress related cardiovascular health, our results suggest potential effects on health outcomes as a reaction to perceptions of unfair exchange at work. In other words, we would expect that if perceptions of unfair pay constitute a chronic source of stress, unfair pay should be negatively related to health status. In the following we investigate this issue in the context of the German labor market by analyzing data from the German Socio-Economic Panel Study (SOEP). Of course, one should interpret cross-sectional field results with care: unlike with the experimental data we cannot exclude the possibility of reversed causality. Nevertheless, we think that exploiting complementarities between controlled lab and large-scale field data is useful and that finding similar patterns in lab and field data is suggestive for the importance and systematics of fairness perceptions and health outcomes.[10]

The SOEP is a representative panel survey of the adult population living in Germany. All members over the age of 17 of a household in the sample are asked for a wide range of

[10] For a discussion of lab and field data, see Falk and Heckman (2009).

personal and household information, and for their attitudes on assorted topics.[11] Each wave records information on the respondents' current labor market status, including wages. The 2009 wave of the SOEP included an item regarding perceived fairness of wage payments. In particular the question asks: "Do you consider the income that you get at your current job as fair?" Possible answers were either "yes" or "no". The 2009 wave also contains items about health status, in particular about subjective health status in general and whether various diseases have been diagnosed in the past. The question about health status in general reads as follows: "How would you describe your current health status?". Responses were given on a five-point scale ranging from "very good" to "bad". While subjective health indicators have their limitations, previous research in health economics suggests that responses to subjective health status questions predict labor market outcomes, health impairments and mortality.[12]

A more "objective" measure can be constructed from answers to the question whether a physician has "ever diagnosed" a particular disease, mentioned in a list. Analyzing responses to this question is particularly interesting as it allows a more precise test of our hypothesis: Since impaired cardiac autonomic control is of particularly significance for cardiovascular health, we hypothesize that perceptions of unfair pay predict stress related diseases such as heart disease, blood pressure and depression, rather than diseases such as cancer or asthma. Finding such selective associations would suggest that fairness affects cardiac control and that the effects measured in the lab extend to our large representative sample. We first show results for general subjective health status before we discuss specific health outcomes.

[11] For more details on the SOEP, see www.diw.de/gsoep/ and Schupp and Wagner (2002).
[12] For a comprehensive discussion of the literature, measurement issues, reporting biases and effects on labor market outcomes, see Currie and Madrian (1999). They discuss potential limitations of subjective health measures but also point out that self-reported measures are good indicators of health as they are highly correlated with medically determined health status. The authors thank Janet Currie for suggesting to check for selective associations.

In Table 4 we report OLS estimates in order to assess how health status is related to perceptions of unfair pay.[13] Column (1) shows a highly significant fair wage coefficient (t-value: -10.50). Respondents who consider their income as fair report a significantly better health status. Since fairness perceptions may simply reflect higher wage levels we control for net wages. We also control for age and gender. Higher net wages and age have a significant effect on self-reported health status in the expected directions. Column (2) adds further controls, which may simultaneously affect fairness perceptions and health status, respectively. These include marital status, whether the respondent lives in East Germany, labor market status (e.g., part time vs. full time), educational background, firm size, occupational status (e.g., blue collar vs. white collar) and type of industry. The precise specification and all coefficients are shown in Table A1 in the Appendix. While the effect of net wages gets considerably smaller and insignificant, the fair wage coefficient remains virtually unchanged. This means that irrespective of wage level, educational background, labor market conditions, industry and labor market status, health status is strongly associated with how fair wages are perceived.

[13] We get the same results using Ordered Probit estimations.

Table 4: Relation between subjective health status and fairness perceptions (SOEP)

Dependent variable: subjective health status			
	(1)	(2)	(3)
Fair wage	-0.179***	-0.171***	-0.178***
	[0.017]	[0.018]	[0.019]
Net wage * 1000	-0.053***	-0.018	-0.019
	[0.008]	[0.011]	[0.012]
Age	0.020***	0.017***	0.018***
	[0.001]	[0.002]	[0.002]
Female	-0.002	0.052**	0.048**
	[0.017]	[0.022]	[0.023]
Constant	1.801***	1.988***	1.936***
	[0.033]	[0.141]	[0.162]
Further controls	no	yes	Yes
Sample restriction	no	no	Yes
Observations	10,279	8,784	8,063
R-squared	0.083	0.124	0.127

OLS estimates, standard errors in brackets. The dependent variable measures the subjective health status on a five-point scale from "very good" to "bad". ***, **, * indicate significance at 1-, 5-, and 10-percent level, respectively. "Fair wage" is a dummy variable equal to one if the respondent answered the question "Do you consider the income that you get at your current job as fair?" with "yes" and zero otherwise. Additional controls include marital status (married, widowed, divorced), whether the respondent lives in East Germany in 2005, labor market status (working in public sector, tenure, full time and part time experience), educational background (highest schooling degree: (Realschule, Fachoberschulreife, Abitur, other schooling degree, no schooling degree, missing), dummies for firm size (below 5, 6-10, 11-20, 21-100, 101-200, 201-2000, more than 2000, missing), occupational status (unskilled blue collar worker, blue collar craftsman, blue collar foreman, blue collar master, white collar unskilled, white collar skilled, white collar craftsman, white collar master, white collar high qualified, white collar management, civil servant, civil servant intermediate, civil servant high, civil servant executive), industry code (agriculture, energy, mining, manufacturing, construction, trade, transport, bank/insurance, services, missing). Sample restrictions imply excluding the inactive (military and civil service, disabled), those who just started in the current firm and whose income information therefore does not refer to the current employer, self-employed, and those with net wage of zero. For more detailed information see Table A1 in the Appendix.

In Column (3) of Table 4 we exclude some employees for whom the relation between fairness perceptions of their income and health status is less plausible. This includes in particular those employees who just started in their current firm and whose income information (net wage) therefore does not refer to the current employer, as well as self-employed employees who largely determine their income themselves. Results in Column (3) show that the fair wage coefficient is slightly larger than in Column (2). Inspecting all coefficients in Columns (2) and

(3) of Table A1 reveals that most control variables have no significant effect on health status such as industry or firm size. However, there are notable exceptions such as gender and occupational status. The higher qualified an employee, the better is his or her health status. There is also a strong effect of personality measured in terms of the Big-5 inventory. Conscientiousness, extraversion and agreeableness are all positively related with better health conditions.[14] Neuroticism, on the other hand, is strongly negatively associated with health.

We now move on to the analysis of specific diseases. Table 5 summarizes results from 27 regressions using the same specifications as in Columns (1) to (3) in Table 4 for nine specific diseases listed in the SOEP survey.[15] We also constructed a Body Mass Index (BMI) as an additional "objective" health outcome.[16] Since, with the exception of BMI, outcomes are binary (diagnosed vs. not diagnosed) we use Probit estimates. The stars indicate significance of the fair wage coefficient, "n.s." indicates non significance. We hypothesized that the fair wage coefficient should be selectively significant for diseases that are related to stress and impaired cardiac control. This is largely what we find: While perceptions of fairness have a highly significant effect on heart disease and blood pressure and to a lesser extent on depression, we find only weak or insignificant results for BMI, cancer, asthma, apoplectic stroke and migraine. With the exception of diabetes, which is also highly significantly related to fairness perceptions, we thus find very plausible selective associations. In sum, the results from our representative data analysis yield similar and supporting conclusions to our findings from the lab.

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[14] The Big-5 can be broadly classified as follows: Openness to experience (appreciation for art, emotion, adventure, and unusual ideas; imaginative and curious), conscientiousness (a tendency to show self-discipline, act dutifully, and aim for achievement), extroversion (a tendency to seek stimulation and the company of others), agreeableness (a tendency to be compassionate and cooperative rather than suspicious and antagonistic towards others), neuroticism (a tendency to easily experience unpleasant emotions such as anxiety, anger, or depression).

[15] All regressions are available on request.

[16] BMI is often used as a health indicator (see Currie and Madrian (1999). Since BMI is not a binary variable we ran OLS instead of Probit regressions.

Table 5: Relation between specific diseases and fairness perceptions (SOEP)

	Significance of the fair wage coefficient		
Disease	**Model (1)**	**Model (2)**	**(Model 3)**
Heart disease	***	***	***
Blood pressure	***	***	***
Diabetes	***	***	***
Depression	*	*	*
Body Mass Index	*	n.s.	*
Cancer	n.s.	n.s.	n.s.
Asthma	n.s.	n.s.	n.s.
Apoplectic stroke	n.s.	n.s.	n.s.
Migraine	n.s.	n.s.	n.s.

Regression models (1) to (3) refer to the exact same specifications as in Columns (1) to (3) in Table 4. We use Probit estimations, except for Body Mass Index (OLS). ***, **, * indicate significance of the fair wage coefficient at 1-, 5-, and 10-percent level, respectively. "n.s." indicates non significance.

4. Concluding remarks

In this paper we have established a causal link between the experience of unfair pay and heart rate variability: A higher mismatch between actual pay and fair pay goes along with lower heart rate variability. Low heart rate variability reflects stress and an impaired balance between the sympathetic and the vagal nervous system, and has been shown to predict coronary heart disease in the long run. Our findings therefore suggest that perceptions of unfair pay affect the efficiency of labor relations not only by reducing work morale, but also by adversely affecting the health status of the workforce. In line with this argument we report regression results based on a large representative data set (SOEP) showing that health status is in fact negatively correlated with subjective perceptions of unfairness. Moreover, we discuss outcomes on specific diseases and show selective associations that are predicted if fairness perceptions affect the nervous system.

On a more general level our findings show that our body registers and systematically processes social and cotextual information (see also Fliessbach et al. 2007). We find that perceptions and beliefs can have important physiological consequences. In our representative data we show that on top of actual life circumstances, such as net wages and labor market status, mere perceptions about fair treatment are correlated with adverse physiological responses. Given that health affects labor market outcomes, this suggests an important potential feed-back mechanism: Labor market experience induces fairness perceptions with consequences for health, which in turn affect labor market outcomes. This environment-belief-body feedback mechanism suggests potential viscous circles and complementary effects, which deserve further study in future work.

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Appendix

Table A1: Relation between subjective health status and fairness perceptions (SOEP)

Dependent variable: subjective health status			
	(1)	(2)	(3)
Fair wage	-0.179***	-0.171***	-0.178***
	[0.017]	[0.018]	[0.019]
Net wage * 1000	-0.053***	-0.018	-0.019
	[0.008]	[0.011]	[0.012]
Age	0.020***	0.017***	0.018***
	[0.001]	[0.002]	[0.002]
Female	-0.002	0.052**	0.048**
	[0.017]	[0.022]	[0.023]
Public sector		0.018	0.018
		[0.026]	[0.027]
Tenure		-0.001	-0.001
		[0.001]	[0.001]
Experience full time		0.005**	0.004*
		[0.002]	[0.002]
Experience part time		0.003	0.002
		[0.003]	[0.003]
Realschule		-0.028	-0.011
		[0.025]	[0.026]
Fachoberschulreife		0.014	0.024
		[0.040]	[0.041]
Abitur		-0.067**	-0.037
		[0.031]	[0.033]
Other schooling degree		-0.035	-0.018
		[0.043]	[0.046]
No degree		0.126	0.163*
		[0.085]	[0.094]
In school		0.015	-0.016
		[0.142]	[0.394]
School info missing		-0.049	-0.039
		[0.050]	[0.053]
Lives in East Germany		-0.055**	-0.066***
		[0.022]	[0.023]
Firm size 5		-0.210**	-0.161
		[0.103]	[0.128]
Firm size 10		-0.155	-0.063
		[0.103]	[0.127]
Firm size 20		-0.146	-0.073
		[0.103]	[0.127]
Firm size 100		-0.123	-0.048
		[0.100]	[0.124]
Firm size 200		-0.145	-0.085
		[0.102]	[0.126]
Firm size 2000		-0.148	-0.082
		[0.101]	[0.124]
Firm size above 2000		-0.115	-0.046
		[0.101]	[0.124]
Firm size missing		0.000	0.000
		[0.000]	[0.000]

Dependent variable: subjective health status		
Blue collar unskilled	0.037	0.009
	[0.047]	[0.057]
Blue collar craftsman	0.016	0.016
	[0.035]	[0.035]
Blue collar foreman	0.086	0.088
	[0.065]	[0.065]
Blue collar master	-0.099	-0.094
	[0.096]	[0.096]
White collar master	0.205*	0.210*
	[0.118]	[0.120]
White collar skilled	-0.004	0.009
	[0.037]	[0.040]
White collar unskilled	-0.021	-0.003
	[0.046]	[0.056]
White collar craftsman	-0.082***	-0.078**
	[0.031]	[0.033]
White collar high qualified	-0.143***	-0.142***
	[0.038]	[0.039]
White collar manager	-0.089	-0.100
	[0.072]	[0.074]
Civil servant low	-0.148	-0.138
	[0.200]	[0.199]
Civil servant intermediate	0.025	0.028
	[0.070]	[0.070]
Civil servant high	-0.083	-0.090
	[0.058]	[0.059]
Civil servant excecutive	-0.138**	-0.154**
	[0.069]	[0.070]
Married	-0.000	-0.005
	[0.025]	[0.026]
Widowed	0.004	0.001
	[0.075]	[0.080]
Divorced	0.003	-0.003
	[0.036]	[0.037]
Industry missing	0.044	-0.017
	[0.101]	[0.106]
Industry energy	0.093	0.047
	[0.117]	[0.119]
Industry mining	0.093	-0.028
	[0.184]	[0.188]
Industry manufacturing	0.018	-0.026
	[0.084]	[0.087]
Industry construction	0.005	-0.049
	[0.085]	[0.088]
Industry trade	0.059	-0.015
	[0.085]	[0.088]
Industry transport	0.072	0.006
	[0.090]	[0.094]
Industry bank/insurance	0.038	-0.019
	[0.093]	[0.096]
Industry services	0.029	-0.026
	[0.083]	[0.087]

Dependent variable: subjective health status			
Openness		-0.011	-0.013
		[0.010]	[0.010]
Conscientiousness		-0.066***	-0.066***
		[0.010]	[0.010]
Extraversion		-0.025***	-0.024**
		[0.009]	[0.010]
Agreeableness		-0.048***	-0.050***
		0.016	0.016
Neuroticism		0.104***	0.110***
		[0.009]	[0.009]
Constant	1.801***	1.988***	1.936***
	[0.033]	[0.141]	[0.162]
Observations	10,279	8,784	8,063
R-squared	0.083	0.124	0.127

OLS estimates, standard errors in brackets. The dependent variable measures the subjective health status on a five-point scale from "very good" to "bad". ***, **, * indicate significance at 1-, 5-, and 10-percent level, respectively. "Fair wage" is a dummy variable equal to one if the respondent answered the question "Do you consider the income that you get at your current job as fair?" with "yes" and zero otherwise. Additional controls include marital status (married, widowed, divorced), whether the respondent lives in East Germany in 2005, labor market status (working in public sector, tenure, full time and part time experience), educational background (highest schooling degree: (Realschule, Fachoberschulreife, Abitur, other schooling degree, no schooling degree, missing), dummies for firm size (below 5, 6-10, 11-20, 21-100, 101-200, 201-2000, more than 2000, missing), occupational status (unskilled blue collar worker, blue collar craftsman, blue collar foreman, blue collar master, white collar unskilled, white collar skilled, white collar craftsman, white collar master, white collar high qualified, white collar management, civil servant, civil servant intermediate, civil servant high, civil servant executive), industry code (agriculture, energy, mining, manufacturing, construction, trade, transport, bank/insurance, services, missing). Sample restrictions imply excluding the inactive (military and civil service, disabled), those who just started in the current firm and whose income information therefore does not refer to the current employer, self-employed, and those with net wage of zero.